

**Direct Fire to Indirect Fire:
Changing Artillery for The Future?**

**A MONOGRAPH
BY
Major Dave Wellons
United States Army**



**SCHOOL OF ADVANCED MILITARY STUDIES
UNITED STATES ARMY COMMAND AND GENERAL STAFF COLLEGE
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ABSTRACT

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In 1907 the artillery community initially codified indirect fire concepts learned during the period between the US Civil War and the Russo-Japanese War. These initial concepts identified the scientific elements of the indirect fire problem. Widespread distribution of the new doctrine throughout the artillery community did not occur until forces were committed into combat in France. Because the US was not a party to the war in Europe during the early years of World War I, the American people and its Army remained isolated from the war. By choosing isolationism as a national policy the President and the Congress chose not to fund preparations for the massive build-up that occurred in 1917. U.S. artillery entered the war in France lacking both the equipment and the experience necessary to provide effective indirect fire. Lessons learned from World War I were captured in artillery notes, doctrinal manuals and in the findings of post World War I boards. The findings and lessons learned from World War I continue to influence artillery doctrine today.

An examination of the key findings of the Hero, Caliber, and Trench Mortar Boards reveals that the findings of these boards continue to influence doctrine and equipment. The Hero board established the need for officer and NCO training, defined artillery organizational structure, and recommended motorization of the artillery. The Caliber Board identified the primary calibers and types of weapons employed at Division, Corps and Army levels, as well as recommending motorization or mechanization of the artillery. Meanwhile the findings of the Trench Board resulted in the demise of Army's heavy mortars since the combat arms branches chose not to sponsor the program. Comparison of current army doctrine, to the board findings reveals that current cannon doctrine still reflects the experiences of World War I.

The codification of the science of artillery has benefited both maneuver and artillery units because the science of artillery has improved the accuracy of the weapons employed. Likewise the application of meteorology, and radars improved the science of artillery and, thus, was implemented rather effectively. The application of new technology such as radios, computers and MLRS has provided new capabilities that must be incorporated in future artillery doctrine. While the MLRS community has applied these new technologies to change doctrine, the cannon community has been slow to adopt new procedures and organizational structures. Consequently, the conditions shaping today's artillery decisions are similar to conditions that allowed the United States artillery to enter World War I unprepared.

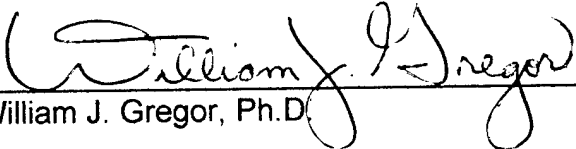
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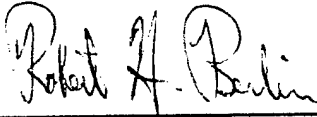
Major Dave Wellons

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Approved by:



William J. Gregor, Ph.D. Monograph Director



Robert H. Berlin, Ph.D. Professor and Director Academic
Affairs, School of Advanced
Military Studies



Philip J. Brookes, Ph.D. Director, Graduate Degree
Program

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INTRODUCTION

“It is harder to do without artillery than without cavalry: artillery is the principal agent of destruction, and its use in action is more closely coordinated with the infantry’s”

Clausewitz in *On War*¹

Artillery has been called the King of Battle because it brings to the field of battle greater destructive power than the infantry. Throughout modern history armies have relied on artillery firepower to defeat the enemy. Artillery established its place on the European battlefield during the seventeenth and eighteenth century as a part of the armies of Gustavus Adolphus, and Fredrich the Great. Although those commanders expanded the 17th and 18th century practices of artillery during their reigns, their changes were minor compared to the changes required by the introduction of indirect artillery fire during the late 1800s.

Toward the end of the nineteenth century, advances in metallurgy, casting and ammunition increased the range of military weapons. The rifle replaced the smooth bore musket and thus, provided the infantry a weapon that now possessed a range equal to that of the cannon. A battery of guns could no longer fire directly upon an advancing enemy without becoming engaged by infantry rifle fire. The adoption of the rifle with its greater range forever changed field artillery doctrine by “driving” the cannon and its crew from the front lines. In response, technology was developed to create cannons and munitions capable of firing longer ranges to support the infantry. Prior to the invention of long-range artillery weapons artillery had been primarily a direct fire weapon. To protect the battery, commanders moved the artillery pieces to the rear of the infantry, out of rifle range. In order to fire at the enemy over the heads of friendly infantry the artillery developed new procedures for firing artillery from protected or out of sight locations. These artillery fires became known as indirect fires.

Indirect fires were not widely used until the Japanese employed indirect artillery fire against the Russians during the Russo-Japanese War. At the time of the Russo-Japanese War British, French, and American artillery communities had not established indirect fire procedures. However, the international military observers were impressed by the results achieved by the Japanese. After observing the successful Japanese use of indirect fire techniques other armies adopted similar procedures. The U.S. Army codified its indirect fire procedures in the 1907 *Field Artillery Drill Regulation*. That regulation established the technical procedures that governed U.S. artillery during World War I and has influenced artillery doctrine and tactics since².

The introduction of indirect fire procedures changed artillery science. A cannon was no longer aimed by sighting down the cannon barrel to place direct fire upon the enemy; now cannons were aimed indirectly using telescopic sights, aiming points and survey techniques. Since a battery of guns could no longer fire directly upon enemy forces, new mathematical calculations were now necessary to place projectiles on the enemy position. The 1907 drill regulation outlined the rudimentary procedures drawn from the technical and scientific aspects of artillery. After World War I artillery science was further advanced by the work of three post war boards: the Hero, Caliber, and Trench Mortar Boards. These boards focused on identifying the key lessons learned from World War I and proffered recommendations for the future. Those findings were so significant their implementation is still evident in today's U.S. artillery.

The persistence of the post World War I concepts, however, does not prove their contemporary usefulness. Current and planned artillery weapons utilizing automated targeting and fire control systems are more powerful and accurate than weapons first controlled by 1907 and post World War I regulations. This long persistence of the post World War I concepts

suggests that the potential of today's new weapons are neither fully leveraged nor understood because they are thought of as an extension of earlier systems rather than as entirely different weapons." This paper addresses the question, "Are the post World War I findings and subsequent doctrine valid for future artillery employment?" To answer that question, two other questions must first be answered. First, "What were the significant findings and doctrinal outcomes of World War I?" Understanding significant outcomes of the World War I experience will make it possible to understand the technical and tactical basis for the artillery doctrine that followed. By comparing the findings and doctrinal concepts of the post World War I era to today's artillery, it is possible to answer the second question: "What concepts from the post World War I era influence today's artillery?" When that comparison is made it is clear that current artillery systems are an extension of the past. Since today's weapons are an extension of the past, future weapon systems such as smart munitions, truck mounted MLRS, and Crusader likewise are likely to be understood also as extensions of the past.

It is not necessary to examine every aspect of artillery development in each period to assess the changes in artillery doctrine. Three common factors provide for a useful comparison. The three factors are threat capabilities, advancing technologies and changing tactic, techniques and procedures (hereafter referred to as tactics, techniques and procedures). Threat capability looks at the unique capabilities and doctrine employed by the enemy during World War I. Advancing technology are the significant changes in weapon capabilities and ammunition utilized by the allied forces. Tactics, techniques and procedures are the developments in artillery standard operating procedures adopted by foreign or US artillery. These three criteria establish a common framework with which to assess post World War I, present and future artillery weapons,

organizations, and tactics. The assessment begins with the development of artillery prior to World War I.

PRE-WORLD WAR I DEVELOPMENTS

During the years between 1898 and 1918, the [U.S] War Department introduced new field pieces, adopted indirect fire, organized the School of Fire for Field Artillery, separated the field artillery from the coast artillery, grouped batteries into battalions and regiments, and integrated the field artillery into the division.³

Between 1898 and 1918 the US War Department attempted to modernize the artillery left over from the Civil War. Congress, and the American people, however, saw no external threat to their homeland and, thus, maintained only a small regular Army. Congress expected to rely on the National Guard to fill any wartime requirements should they arise. Since large stockpiles of equipment remained from the Civil War, Congress was reluctant to provide funds for modernization. Because the U.S. Army lacked military research funds during the period between the Civil War and World War I, the U.S. Army only watched as other nations developed the new technologies.

Three technological advancements, rifled tubes, breech loaded cannons and invention of a recoil system, produced rapid firing long-ranged cannons prior to the start of World War I. Prior to 1870, improvements in range were limited by cannon design. Muzzle loaded cannons of the 1800s were inaccurate and lacked the range necessary to engage infantry armed with rifles. To solve this problem, experiments with rifled artillery tubes and breech-loaded cannons were conducted. Every country developed rifled cannon barrels. Transferring the concepts of rifled barrels to cannons began before the civil war. While cannons were loaded from the muzzle, the

addition of rifling could and did not increase the cannon's range because the propellant gases could not be adequately contained within the barrel. Range increased when a successful breech-loaded weapon was developed. Two countries, Germany and France developed the first successful breech-loaded weapons. German manufacturers Krupp and Nordenfelt developed a sliding-wedge breechblock, while the French developed an interrupted screw breechblock⁴. Both of these systems solved the problem of loading a cannon from the muzzle. By loading projectiles from the breech, a tighter fit was achieved between the projectile and the cannon, thereby increasing the muzzle velocity of the projectile. Increased muzzle velocity produced cannons that shot further. Table 1 provides a comparison of Civil War and 1913 artillery ranges and demonstrates the increase in range that results breech-loading technology.

Civil War Era:

Weapon / Model	Projectile	Elevation in degrees	Range in yards
M1841 6-pounder	Shot	5	1,525
M1857 Napoleon	Shot	3.45	1,680
10 Pound Parrot	Shell	10	3,000
	Shell	20	5,000

Pre-World War I:

Weapon / Model	Projectile	Elevation in degrees	Range in yards
M1905 Howitzer (3.8 inch)	Shrapnel High	45	6,300
	Explosive shell		6,300
M1906 Howitzer (6 inch)	Shrapnel High	45	8,700
	Explosive shell		
	6 inch	Explosive shell	

Table 1, Artillery Range Comparisons: From US Civil War to 1914

Besides increasing the range of post Civil War artillery, breech loaded cannons provided additional benefits. Gunners now loaded the cannon from the rear of the piece, which provided

the crew more protection from infantry fires than muzzle loaded cannons. New projectiles, shrapnel and explosive shell, requiring breech loaded cannons were utilized in World War I instead of the less accurate shot and canister rounds of the Civil War. While breech loaded cannons increased the range of the artillery they did not solve the problem of the gun rolling out of position (referred to as out of battery). A cannon rolled backwards to take up the "recoil" from each shot and the crew had to roll the gun back into battery before firing again. The French solved the "out of battery" problem by designing a recoil system to compensate for the movement of the cannon during firing. The new recoil mechanism incorporated a hydro-pneumatic recoil system that not only absorbed the recoil but also returned the gun to the original firing position after each shot. This recoil mechanism was incorporated in the French 75mm Field Gun in 1897. The "French 75" as it came to be known, implemented all of the latest advancements in one weapon: an interrupted screw breech, a new recoil system and a new independent sight system. Together all of these changes allowed a gun crew to fire nearly twenty rounds per minute. Rapid firing guns were now technologically available for nations entering World War I. The United States relied on the French 75 during World War II.

Although the French 75 incorporated state of the art technologies and allowed for indirect firing, American and European armies still relied on the direct fire techniques they used on their older and more numerous guns. Older guns could not elevate beyond 10 degrees; thus projectiles were fired along a flat trajectory. These low angle fires presented a serious problem for an artillery unit firing from behind the infantry. To overcome this disadvantage, gunners often placed their weapons near the high ground to ensure the shell's trajectory cleared the infantry and other intervening obstacles. This practice soon changed after American observers reported the surprising effects of Japanese indirect fires during the 1904-1905 Russo-Japanese War.

In 1904 on the Manchurian Peninsula a war between the Russians and Japan, demonstrated the potential of a new way to fire artillery. Fires were placed on enemy forces out of the direct line of sight. At the Battle of Sha-hoon, 1 September 1904, the Japanese deployed their batteries on the reverse slopes of a hill to protect them from Russian counterbattery fires. These indirect fires were controlled by the battery commander, who was located well forward of the firing battery position with the infantry. As a forward observer, the Japanese commander directed the fires of his battery onto the enemy artillery while Japanese gun crews employed indirect fire from concealed positions. The battery shelled unseen targets and silenced Russian field pieces that had been placed in the open to provide direct fires. Although the Russians had modern, rapid-fire guns, they had difficulty hitting the Japanese batteries hidden back in the valleys behind the hills.⁵ American Army observers were impressed by the Japanese successes and recommended the adoption of indirect fire techniques.

Two years later in 1907, under the direction of Brigadier General Story, Chief of the Field Artillery, the American Army introduced the doctrine of indirect fire in an artillery crew drill manual, *Field Artillery Drill Regulation* (1907).⁶ It codified the technical procedures required to implement indirect firing including tactics, techniques and procedures for indirect lay, fire mission computations and forward observer procedures. The new indirect lay procedures enabled a firing battery to be dispersed across the terrain while massing platoon and battery fires on distant targets. The targets were usually not visible from the gun's location and firing required a forward observer, usually the battery commander, to observe and adjust fire on to the target. Co-located with the infantry, the battery commander determined corrections to the firing data and relayed the corrections through a signal operator to the guns. He communicated his corrections to his battery with signal flags, electric buzzers using Morse code or a field

telephone⁷. The indirect fire process introduced in the 1907 drill regulation was radically different from the procedures that had been used as recently as the Spanish-American War.

The 1907 drill regulation focused on battery and crew level drill, reinforcing the role of the firing battery as the basic firing unit for indirect fires. The basic firing unit had previously been the battery for cannons utilizing direct fire and this standard was carried forward into the 1907 regulation. Artillery fires were planned and executed by massing a battery against a target. Battery commanders directed and controlled their unit's fires. Individual cannon crew drills and platoon operations were described in the manual but were subordinated to the emphasis placed on the battery.

Utilizing the battery as the basic firing unit, the regulation emphasized the importance of fire support to the infantry and identified four types of fire missions: continuous fires, volley fire, zone fire, and fire at will. These four missions are similar to missions or methods of fire control found in today's artillery doctrine. Continuous fires are similar to today's final protective fires. Volley fires became the standard fire mission for battery or larger artillery formations. Zone fires are similar to a little used procedure known as sweep and zone, and fire at will is a method of control for standard fire missions referred to as fire "when ready". Artillery commanders could utilize direct or indirect fires to support the infantry

When the world entered World War I, artillery technology had solved the artillery's range problem. Countries built or bought breech-loaded cannons capable of firing projectiles greater than 4,500 yards, well beyond the range of a sighted rifle. These rapid firing cannons were capable of destroying enemy works by either direct or indirect fire. While this new equipment was readily accepted, the doctrine of indirect fire, however, was not fully adopted until more artillery commanders were trained in indirect fire procedures. Changing traditional artillery from

direct fire to indirect fire procedures took several years. Aware of the changing doctrine in foreign countries, the U.S. Army published its own doctrine for indirect fire artillery in the 1907. Even though U.S. doctrine was introduced years before the start of World War I Congress maintained its isolationist policies which meant funds were not provided for officer schooling and new equipment fielding. Consequently, the widespread implementation of this new doctrine was delayed. Thus, the U. S. Army patiently watched from the sidelines when Germany fought Britain and France at the outset of World War I.

In contrast, in Europe French and British forces prepared for war. Their preparations and experiences from the Franco-Prussian War, Boer War and as observers in the Russo-Japanese War influenced their artillery tactics, techniques and procedures. French and British artillery doctrine during the early World War I years directly shaped U. S. doctrine when U.S. forces entered the war in 1917.

Pre-World I Technology and tactics, techniques and procedures - French and British

French experience from the Franco Prussian War led French military leaders to believe that any European war would involve infantry formations and would end quickly. General Herr, a former artillery commander of the French VI Corps predicted, "war will be short with rapid movement . . . a struggle between two infantries . . . the artillery will be only an accessory arm, with one task: to support infantry attacks . . . it will require only limited range."⁸ The French organized their artillery and framed their doctrine to support this view of a short violent war between two infantry armies. When France mobilized in 1914, they fielded 3,840 75mm guns and only 384 heavy guns which clearly shows the French preference for close support flat trajectory guns. Since close support to the infantry was the primary mission of the artillery, the

dominant firing method was short bursts of neutralizing or demoralizing fires known as “rafales.”⁹ British experiences likewise shaped the doctrine and equipment they took to war.

Lessons learned from the Boer and Russo-Japanese Wars influenced how the British planned to use artillery during the early years of World War I. During the Boer War British artillery could not keep up with the infantry across the rough South African terrain. British doctrine called for the artillery battery to assist the infantry by establishing fire superiority over the enemy.¹⁰ To ensure superiority commanders attempted to keep up with the infantry. Poor mobility in rough terrain limited the artillery's use of indirect fire because the guns required more set-up time for indirect fire than direct fire methods. Indirect fires also required precise fire control systems, extensive mathematical calculations, observers forward of the guns, and a means of communication between the guns and the observer. Those requirements made the delivery of indirect fires slower than direct fire. As a result cannon crews relied on the faster methods of direct fire artillery and infantry commanders preferred the responsiveness of direct fire artillery. That experience reinforced the demand for lightweight rapid firing guns employed in support of advancing infantry. During the Russo-Japanese War, the British observed the Japanese indirect fires but noted that large quantities of ammunition were needed to destroy the enemy. British artillery officers were convinced that destruction of enemy artillery and enemy works required too much ammunition. They proposed that artillery fires should focus on neutralizing or demoralizing the enemy instead of destroying him. As a result the BEF entered the First World War with the belief that indirect fire techniques were unsuitable during periods of rapid mobility and when used should neutralize or demoralize, not destroy the enemy.¹¹ Both British and French armies, therefore, entered World War I favoring lightweight rapid firing guns or howitzers. In contrast to the French and the British German artillery entered World War I with

a well trained artillery organization armed with a variety of light, medium and heavy caliber weapons.

WORLD WAR I

When the war broke out in Europe, Germany experienced early successes. They reached the Marne before allied forces halted the German advance. Unlike the Allies, the German army used firepower in support of mobile warfare. Artillery firepower was essential to maintain the momentum of advance. From the out set of the war Germany used howitzers to neutralize the French 75s, and heavy artillery to destroy French and Belgian fortifications. Unlike France, Germany used field artillery fires to neutralize as well as destroy the enemy. The German army held a more balanced view of the field artillery's role¹². To control massed fires Germany centralized command and control of the artillery and developed artillery staffs at division and corps. The allies subsequently adopted these German artillery concepts during the later years of World War I.

In 1915, the battle lines between the allies and the central powers became a fixed line of trenches that produced a general stalemate. Infantry weapons, particularly the machine gun, and improved obstacles and barbed wire, created a static battlefield upon which only artillery firepower could produce the conditions for maneuver. Artillery preparations became a prerequisite for assaults across the entrenched or well-fortified infantry positions. Initially indirect fires were targeted against enemy forces in the trenches in an effort to neutralize their small arms fires while allied forces attacked. The curved trajectory of the howitzer allowed artillery units to fire from protected locations while the attacking infantry were positioned in the forward trenches. During battles in 1915 and 1916, both the British and the French attempted rolling barrages

ahead of the assaulting infantry. That technique was frequently ineffective because Germans withdrew from the forward trenches during the bombardment only to return to their fighting positions before allied troops could reach German positions. As a consequence, the Germans inflicted heavy casualties upon advancing troops. Rolling barrages or neutralization fires were effective only as long as the fires remained on the objective. Timing and controlling such fires was difficult to execute in conjunction with advancing infantry. Since fires were often ineffective, planners shifted from neutralization fires to destructive fires against enemy works and barbed wire entanglements.

During 1915 and 1916 French and British attempts to use destructive fires consumed large quantities of munitions in short periods of time. The new emphasis on destruction required centralized command and control procedures to manage and control ammunition consumption. Since the British Expeditionary Forces (BEF) relied on battery fires to support their infantry they had neither artillery organizations above division level nor sophisticated artillery staffs and headquarters to manage the resources required by trench warfare. The British established division and army level artillery staffs and headquarters to solve the problem of artillery command and control. Meanwhile, the French drew upon their reserve artillery units at Corps to assist with the management of artillery resources. As US Forces entered the war, they too developed regimental, division, corps and army level artillery headquarters to manage the vast quantities of ammunition and equipment necessary to break the enemy lines.

Compounding the problem of consumption was the battlefield damage caused by artillery preparations. Bombardments restricted or degraded the mobility of infantry, armor and artillery units across the devastated terrain. The beaten zone, now known as "No Man's Land" made forward movement nearly impossible. During 1915-16, the allies experimented with aerial

observers, and unobserved fires in an attempt to break the trench stalemate. Initially the airplane was used for reconnaissance, to look over and into the trenches. Realizing the value of these overhead views the allies began photographing the trench lines in an effort to produce maps. In 1916 as aerial photomaps were prepared, French artillery officers modified their observed fire techniques to compute map-based artillery firing data.¹³ The same mathematical calculations used to prepare observed indirect fires were applied to unobserved fires based upon the aerial photomap. Unobserved fires proved to be a useful tool, allowing the French and British to attack frontline and deep targets without forward observers. Aerial maps provided the data necessary for the fire missions.

Improvements in aerial photography and observed fire techniques soon allowed the allies to shift from destructive fires to fires intended to neutralize enemy forces. Destructive fires consumed large quantities of ammunition in rolling barrages with limited effects. The aerial photomaps allowed more accurate strikes on built-up enemy positions, headquarters and supply points. As the British and French refined their firing techniques, artillery organizations and equipment American observers reported these improvements to the U.S. War Department. The lessons learned were incorporated into the US doctrine when U.S. forces entered the war.

World War One - US Technology and tactics, techniques and procedures

Despite these reforms, the United States entered World War I without sufficient field artillery and had to rely upon the Europeans to arm its batteries.¹⁴ Pre War budgets had precluded modernization of artillery equipment and limited the training for non-commissioned officers and regular army officers. After war was declared the US Army artillery grew from 25 to over 200 artillery regiments in 1918¹⁵. This rapid mobilization of newly formed artillery

regiments strained the War Department's ability to equip and train its artillerymen. In the Annual Report of the Chief of Artillery in 1919, General Snow reported, "Conditions of the field artillery in January 1918 may be characterized as chaotic."¹⁶ His reference to the chaos is a direct reflection of the challenges of reopening and expanding the School of Fire and other brigade level artillery training centers. Training raw recruits took two to four months before deployment to France. Compounding the situation, the War Department could not equip the deploying forces. To fill the shortfalls the AEF "borrowed" French-made artillery pieces to equip the units and conducted training in France.

As the U.S. prepared to enter the war in October 1917, the War Department issued a new drill regulation, *Drill and Service Regulations for Artillery -1916*. That regulation stated that the artillery's primary mission was to neutralize hostile enemy artillery. Once the enemy was in small arms range, the artillery's mission shifted to close support to disrupt and delay the movement of reinforcements to the front lines.¹⁷ Shifting the artillery mission from supporting the infantry to neutralizing the enemy's artillery developed after observing German artillery effects on allied forces. To control these specialized fires, artillery headquarters were established at Corps and Army level. Counterbattery fires were assigned to Corps artillery units, while division artillery headquarters were responsible for supporting the regiments and battalions of artillery. The 1916 regulation continued to identify the firing battery as the basic artillery unit responsible for providing fires to supported infantry units. After observing British and French preplanned fires, observers from the War College translated British and French doctrinal manuals and published their findings in *General Notes on the Use of the Artillery, 1917*.

General Notes on the Use of the Artillery documented experience from the European theater and focused on the technical aspects of artillery employment. Within it are found

doctrinal explanations regarding the tactical execution of counter-battery fires, fires on enemy works, and fires with gas shells. The essential requirement of counter-battery fires was the destruction or neutralization of enemy guns. Fires upon enemy works focused on the trenches, barbed wire, permanent fortifications, villages and railways. The discussion of the use of gas shells was limited to the conditions under which gas shells were effective. *General Notes on the Use of the Artillery* further expanded the basic artillery missions and addressed specific techniques for achieving specialized fires in the offense and defense.¹⁸ Counter-battery fires, fires accompanying the movement of infantry units, and covering fires (fires against enemy works prior to an attack) were designated basic offensive artillery fires. These three offensive fires required indirect firing techniques. Fires in support of the defense were organized into two categories, counter-preparations and barrages. Counter preparations were fires massed on the enemy and his works, while barrage fires were fires placed on the enemy at the moment of the attack (today these are final protective fires). These new techniques, captured lessons learned from Europe, and focused AEF artillery training on the needs of trench warfare.

When, U.S. artillery regiments arrived in France they were equipped with French guns and began training. Because the artillery regiments had been rapidly mobilized, less than one percent of the officers and NCOs in the AEF artillery had more than one year of military experience.¹⁹ In an effort to gain experience for these commanders and NCOs Gen Pershing, commander of the AEF, assigned arriving artillery units to quiet portions of the front for additional training. At these locations, artillery units were formed into training brigades and received three weeks of training using the new artillery doctrine²⁰. While this training better prepared the units for combat the army's rapid mobilization of inexperienced officers and NCOs limited the application of observed indirect fires during the war.

LTC John Anderson writing after the war described the situation on the battlefields of France during 1917 - 1918:

Along with smoke, dust and erratic communications, the mediocre qualifications of officers, non-commissioned officers and enlisted personnel, however, encouraged abandoning observed for unobserved fire. For the most part the Army field artillery furnished solid unobserved fires for trench warfare because for the most part it could be planned in great detail before the battle and permitted officers to take their time calculating fire direction data...²¹

LTC John Anderson's observations captured three key points about the artillery's indirect fire doctrine. First, forward observer training was essential to observe targets attacked by indirect fires. More than minimal skills were required for timely missions. Second, communications were a critical link for observed fires. Inadequate communication, the lack of mobile radios resulted in artillery units firing unobserved or preplanned fires because they were easier to conduct than observed fires. Lastly, and most importantly, the techniques for indirect fires worked. When observed fires were not possible the army resorted to unobserved fires (aerial photomap based fires). LTC Anderson's comments indicate that the doctrine outlined in Drill Regulations of 1907, 1916 and the Artillery Notes of 1917 provided a working technical basis for providing indirect fires.

During the remainder of the war tactics, techniques and procedures for unobserved and unregistered fires continued to change and improve. The AEF learned sound ranging, and muzzle velocity and ammunition management from the allies. Sound ranging, the first of these techniques allowed U.S. artillery to identify and neutralize German guns. Sound ranging or "flash to bang" detection of enemy artillery measured the time for sound to travel from a firing weapon to the observer and allowed the observer to calculate the distance to that target. Developed by the French in 1914; the Americans adopted the tactics, techniques and procedures

in 1917 and established sound ranging units in France.²² The second technique, muzzle velocity and ammunition management, was adopted from British practice during 1918.²³ The first of these procedures, muzzle velocity management, measured tube wear to determine the expected velocity of a fired projectile. Tube wear measurements allowed commanders to quantify the variations in muzzle velocity. By applying these variations in indirect fire calculations units improved the accuracy of artillery fires. To further improve the accuracy of indirect fires units segregated ammunition by manufacturer and lot number. Segregation of munitions ensured that projectiles and powders of similar weight and manufacturing characteristics were fired at the same time that resulted in fires closely massed together. Each of these techniques advanced the technical aspects of applying indirect fire.

As firing techniques became more accurate, they also became specialized. US artillery responded to the static nature of trench warfare by assigning units specific missions. Corps artillery units were assigned the mission of conducting counterbattery fires, while Division artillery batteries were assigned general support missions in support of front line artillery units. Assignment of specific missions to units and their headquarters departed from the former practice of training and organizing batteries to conduct all types of fire missions. Separate unit assignments allowed units to develop specialized techniques for conducting preparations and counter-preparations. Division and Corps artillery units began executing preplanned barrages, and deep fires against the enemy rear. By 1918, artillery conducted deep fires to interdict logistics, artillery positions and command and control headquarters. Counter-battery, programmed, and deep fires although plentiful were never enough to break the stalemate of the trenches. Firepower alone would not solve the problem.

A "breakout" from the trenches did not occur until the British deployed tanks in Northern France in 1918. Tanks allowed the infantry to advance behind the protection of the armored vehicle, itself capable of providing long range fires upon enemy works. Forward movement returned to the World War I battlefield and as units maneuvered deep into enemy held territory, the artillery pursued the Germans with damaging fires. While the tank did not end the war, its introduction and the return of maneuver hastened the end of the conflict. The Germans, nearing exhaustion from four years of war sued for peace 11 Nov 1918.

With the end of the Great War US troops were demobilized and redeployed to the United States. Within 18 months, Congress had returned to domestic issues and the Army was demobilized. The War department concerned about the performance of its units in France created three boards to capture the lessons learned from World War I and to make recommendations for the future.

INTERWAR PERIOD

"Following the Great War, various boards made recommendations for implementing the lesson of 1914 - 1918 and improving the field artillery. Over the next two decades, pacifism, a surplus of material from the war, conservatism, limited budgets, and problems associated with new technology influenced rearming the field artillery and developing new tactics and techniques."²⁴

Immediately after the end of World War I, the War Department examined the U.S. artillery's performance during the war. The War Department convened three boards, under Generals Hero and Westervelt, to record the key artillery lessons from World War I and identify field commander's recommendations for future artillery development. This series of boards reviewed equipment performance, doctrine, training and logistics. Together these boards

identified more than twenty observations about the wartime artillery. Six of more than twenty findings affected post World War I artillery practices and still influences the US Army's use of artillery today. Four of the six major findings were identified by the first board, the "Board to Study Experience Gained by the Artillery in the AEF".

Hero Board

On December 9, 1918 the General Headquarters, American Expeditionary Force (AEF) convened the "Board to Study Experience Gained by the Artillery in the AEF". This board was later referred to as the "Hero Board" after its senior officer. During the four-month investigation, the board researched the organization of artillery units and staffs, ordnance types, motor transport, communications, flash and sound ranging, liaison, ammunition supply, maintenance, and training.²⁵ The board visited AEF units, and solicited comments and examined the battlefield experience of senior commanders and experienced artillerymen. Twenty-one areas were researched and documented in the eight hundred and forty page report written by the board²⁶ The tactics, techniques and procedures and recommendations focused on unit organization, trench mortar assignment, soldier training and artillery mechanization - motorization. Most of the board's twenty-one recommendations dealt with the tactical organization of the artillery at battery, battalion, regiment, division and Corps levels.

The board report recommended standardizing artillery organizations and missions. Field Commanders reported that specific unit mission assignments, centralized command and control; and logistical support for the firing battery were critical for achieving effective artillery fires. At the battery level, the board determined the 1907 and 1917 drill regulations provided adequate doctrinal basis for battery level operations. Field Commanders recommended the proven wartime organizations of three batteries of 75mm guns and two batteries of howitzers at the

battalion level to provide adequate fire support for entrenched and advancing infantry. To improve command and control additional staff officers were assigned to the battalions to preclude tasking batteries for the necessary battalion staff. After addressing the staff officer issue at the battalion, field commanders recommended establishing two separate batteries, headquarters and headquarters battery and service support battery, to support the logistics needs of the battalion²⁷. At the division level, support to the infantry and mobility continued to be the main artillery priorities. The board recommended light artillery: two 75mm or 3 inch gun arty regiments, one 120mm howitzer regiment, and 1 battalion of mountain guns to accomplish those missions. Additionally, trench mortars (120mm or larger mortars) were removed from the Division artillery because they were difficult to move. Corps artillery was assigned the counterbattery and neutralization missions. To accomplish these missions the board members recommended one regiment of 4.7 inch guns, one regiment of 6 inch (155 mm) guns, and one regiment of 155 mm howitzers. The specific assignment of missions and weapons to the battery, battalion, division and corps codified the Division artillery structure. This division artillery structure persists in today's artillery cannon organizations.

The Hero board recommended more than a divisional structure; it also established the concept of general support artillery. During the war, the French and Germans' utilized an artillery reserve or general support type fires controlled by a central headquarters. The board likewise recommended the establishment of a general artillery reserve and the reassignment of trench mortars from the division artillery to this reserve. The general artillery reserve consisted of field artillery guns, heavy tractor drawn artillery, railway artillery, trench artillery, and anti-aircraft artillery²⁸. The general artillery reserve reinforced division, and corps artillery. General artillery reserve fires, referred to as general support fires, provided the general headquarters

commander the additional fires he needed to influence the battlefield during large operations. After recommending the division and echelons above division artillery structure, the board focused on the challenges of training a mobilizing army.

Because the Army had mobilized rapidly in 1917 and 1918 less than one percent of artillery officers in the AEF had more than one year experience. As the U.S. entered World War I Fort Sill received school funding and reopened the School of Fires. Although training at the School of Fires prepared recruits and NCOs for deployment to Europe the six-week course did not provide artillery leaders the experience necessary for synchronized fires. This lack of experience was evident on the battlefield. Observers failed to integrate artillery fires with the movement of advancing infantry. During the battle of the Marne, the supporting artillery preparations out ran infantry's advance, exposing them to German machine gun fire. Adjusting preplanned fires to match the actual rate of advance required more experience than either artillery or infantry officers possessed. As a result the board found that "schooling for general, field grade and staff officers of both infantry and artillery be conducted for the practical training of artillery operations."²⁹ The requirement for infantry and artillery officer training resulted in the permanent establishment of the artillery school to provide artillery training to active duty and National Guard soldiers. Fort Sill's School of Fire later became the U.S. Army's artillery training center which has provided trained soldiers America's wars ever since.

The Hero Board's significant contribution to artillery doctrine included recognizing advances in artillery organization, removing the trench mortars from the division artillery, and documenting the requirement for training infantry and artillery officers in artillery operations. The board also recommended additional research into artillery mechanization and motorization concepts. That research took place during the second board of the series, the Caliber Board.

Caliber Board

The second board assigned to review the equipment of the AEF was the Caliber Board³⁰. General Snow, Chief of Field Artillery, asked the War Department to conduct a study of foreign artillery. During the war he had expressed his grave concerns about the U.S. Army's dependence on French equipment, doctrine and tactics. After the war he forwarded his request to have an independent artillery study conducted to resolve his concerns. The Caliber board convened in France under the direction of Major General William Westervelt in December 1918. Members of the board interviewed French, British, Italian and American officers and studied the ammunition and weapons of the allied and defeated axis powers. At the close of the board's investigation, the board concluded that every gun, howitzer, carriage, vehicle and projectile needed to be replaced.³¹ In addition to replacing the foreign and old US equipment, the board determined that the AEF lacked the proper mix of weapons available and had been dependent on the French 75mm gun, which was unacceptable for future conflicts.³² When the Caliber Board completed its research it made three key findings: U.S. must produce its own weapons and ammunition, the Army must possess a mix of light, medium and heavy artillery, and artillery pieces shown be motorized and mechanized.

Because the Caliber Board recommended replacing all the artillery pieces in currently in the US artillery, the board's recommendations were not limited by past practices. From its survey of French, British and German artillery doctrine the board determined the appropriate mix of weapon types and caliber for future US artillery units. First and foremost, light artillery was recommended for the divisions. The best division artillery pieces were light field guns (75mm to 3 inch) and light field howitzers (105 mm) having a range of at least 11,000 yards. Light field guns were used during World War I, but howitzers were also required to supplement divisional

fires.³³ Corps received medium artillery, 4.7 to 5 inch guns and 155mm howitzers to conduct counterbattery, harassing and interdiction fires. Each of these weapons required a range of 16,000 yards. Heavy artillery (155mm guns and 8 inch howitzer) was assigned to Army level artillery. Guns required a range of 25,000 yards, and howitzers a range of 18,000 yards to accomplish the army level missions. Although the board specified the caliber and range for these new weapons, board members recognized that army funds were limited. The members further recommended an ideal and practical gun howitzer combination for each echelon (See Table 2).

Echelon Assigned	Ideal Caliber	Practical Caliber	Minimum Range (yards)
Division (Light Artillery)	4 in gun	75mm gun	11,000
	105mm howitzer	155 mm howitzer	11,000
Corps (Medium Arty)	4.7 to 5 inch gun	4.7 in gun (M1906)	12,000
	155mm howitzer	155mm howitzer	12,000
Army Heavy Arty Super Gun	8 inch howitzer	155mm howitzer	18,000-25,000
	9 1/2 in howitzer	240mm(8 in) howitzer	25,000
	8 to 10 inch gun		35,000
		8 inch sea coast gun	24,000

Table 2, Caliber Board recommendations - Caliber and Ranges for Artillery³⁴

The weapon caliber and mix recommendations found in the Caliber Report were implemented before the beginning of World War II. After addressing the appropriate weapon mix, members of the Caliber Board addressed General Snow's concern about reliance on foreign weapons and ammunition.

All of AEF artillery weapons, equipment and ammunition had been bought from French and British manufacturers. During World War I, US industry produced only 109 French 75s.³⁵ These 109 cannons were never placed in service in Europe. During World War I a significant number of French time fuses detonated the projectile in the cannon tube, injuring soldiers and destroying valuable cannons. The board reported, "The French Type super quick fuse is

seriously defective in this regard.”³⁶ Reliance on foreign artillery equipment and ammunitions had placed U.S. soldiers at risk. Ammunition and equipment manufactured in the U.S. had faced stricter safety and manufacturing tolerances, and, thus, had produced safer weapons and projectiles. As a result of their findings, the Board recommended U.S. manufacturers produce all future weapons and ammunition³⁷. Reliance on foreign weapons and ammunitions had ended.

Artillery during World War I depended upon horse drawn light artillery. Since the board recommended medium weight and heavy artillery, BG Westervelt and members of the board researched the available studies on artillery mechanization. During the World War I in France the Allied artillery community tested tractor and motor car (light trucks) drawn artillery. Early results from these field tests showed that light tractors and motorization provided a long-term replacement for horses. The board recommended motorizing all guns and howitzers. Light artillery was to use quad-drive trucks either to draw or mount 75mm guns. Heavier guns, like the 155 and the 240mm, were to be mounted on a tractor or tank chassis to form a self-propelled howitzer. Tradition and the lack of funding delayed the implementation of these recommendations. Many units continued to use horses because horses and forage were easily available at US installations and the limited funds available for the post war army between 1919 and 1940. Lack of funds influenced implementation of this final Caliber Board recommendation until World War II began. The last board, the Trench Mortar Board, was more affected by funding than the first two.

Trench Artillery Board

BG William I. Westervelt, known for his work on the Caliber board, convened the third artillery board in 1919. The board was tasked to develop recommendations regarding the caliber, and distribution of trench mortars. Unlike the successful implementation of Caliber Board

recommendations, the Trench Artillery Board recommendation adopting light (160mm) and medium (240mm) mortars but the recommendation was cut short because no funds were available for their purchase. Furthermore, the Hero Board had removed heavy mortars from the division artillery. Consequently, the artillery branch supported neither funding nor research for these weapons. No other branch championed the trench mortar so large caliber mortars disappeared from the army.

Completion of the Trench Mortar Board closed the series of artillery boards studying World War I. These boards sited more than twenty recommendations. The boards had made six findings that significantly influenced the future of US artillery. The six most significant findings were codification of division artillery structure, institution of artillery school training, a detailed list of artillery calibers and weapon types, domestic production of all future Army artillery weapons and ammunition, the mechanization or motorization of the artillery and lastly the elimination of heavy mortars.

CURRENT ARTILLERY DOCTRINE

Although technology has advanced beyond 1919 capabilities, threat capabilities, advancing technologies and changing tactics, techniques and procedures still determine artillery doctrine in 1999. In recent years many foreign countries have acquired new artillery systems and improved munitions that has changed the threat dramatically.

Several nations of the world currently produce artillery weapons or ammunition that shoot farther than US cannon systems³⁸. These nations possess artillery systems that fire projectiles to greater ranges or achieve faster rates of fire than U.S. artillery. Two South African

exported cannons, the self-propelled G-5 and towed G-6 (both 155mm), achieve ranges beyond 30 kilometers with standard munitions and 40 kilometers with base-bleed high explosive munitions. Both of these weapons began production before 1989, more than ten years ago. The Former Soviet Union's 2S19, an auto loading self-propelled howitzer fires ranges of 24 and 29 kilometers with standard and base-bleed munitions. Slower firing weapons such as the Former Soviet Union's 2S5 reaches out to 35 kilometers. Meanwhile, 60 percent of all U.S. artillery is assigned to the National Guard. Those units are equipped with M109A3s³⁹; the standard artillery weapons of the cold war era. The older M109A3 howitzer fired to range of 14.6 kilometers for standard high explosive projectiles.⁴⁰

Interestingly in 1919, the Caliber Board recommended 155mm howitzers with a range of 12,000 kilometers for use at division and corps levels. Nearly seventy years later, standard artillery ranges for the M109A3 barely exceed the standard artillery ranges planned in 1919. The range differential between the M109A3 and foreign cannons prompted the US development of the Paladin, a 155 mm self-propelled howitzer.

The Paladin is being fielded to the active army and is scheduled to replace National Guard howitzers. The Paladin's increased range is achieved by replacing the standard tube of the M109A3 with a longer cannon tube⁴¹. Paladin can fire to a range of 18 kilometers with standard propellants, 24 kilometers with supercharged propellants, and 30 kilometers with rocket assisted munitions. In the future, the Crusader, a 155mm self propelled system under development, will achieve ranges of 30 and 40 kilometers by changing propellant composition and by increasing the length of the cannon⁴². When Crusader begins fielding in 2007, U.S. artillery will achieve range parity with current Russian, German and South African weapons.

Looking back the Caliber Board outlined the caliber and range of future cannons based upon artillery experience gained during World War I and their knowledge of German systems under development by the war's end. As the U.S. artillery community enters the twenty-first century U.S. 155mm cannon artillery systems still exhibit similar characteristics as those findings of the 1919 Caliber Board.

Since the World War II, various countries have experimented and developed long range cannon systems. Most of these systems leveraged the science of ballistics to increase the cannons range. To increase a cannon's range three variables can be altered, the gun tube is longer length, the projectile is propelled faster, or the projectile is modified to improve flight performance. All three of these characteristics of a ballistic projectile have been modified since the Caliber board met.

Today's cannons have been built with longer tubes, and an increased projectile muzzle velocity. These two improvements have increased the range of standard artillery shells out to thirty kilometers. Base-bleed technology improvements have increased cannon artillery ranges to forty kilometers. While cannons are expensive to modify and update, producing base bleed or laser-guided projectiles is comparatively inexpensive for a country requiring increased range and lethality. Currently South Africa, China, and Russia, all manufacture systems employing these technologies. Meanwhile the U.S. has employed some of these technologies while awaiting the development of Crusader. By the time Crusader is fielded in 2007, the system will only match ranges currently attained by these three countries.

During the post-World War I years the Caliber Board recommended systems that outranged the potential threat. Today, like pre-World War I, our potential adversaries outrange

us. To overcome this range difference, new weapons and munitions must be developed requiring additional funding that is currently not available.

Today's funding picture is very similar to the one faced by the Army during 1920's. During the years after World War I the military was reduced to a small constabulary force with limited funds for modernization. During these early interwar years the artillery community tested and experimented with new equipment but did not field new equipment in large quantities because of the lack of funds. Not until just before World War II were large quantities of modern artillery produced. Today we are developing prototypes for the Crusader 155mm self-propelled howitzer and light experimental howitzer. Production of these prototypes has recently been reduced. The Army set the initial production level for Crusader at 1134 howitzers for active duty and National Guard cannon battalions. That production level has been cut to 480 to release military funds for the fielding of the prototype brigades in I Corps⁴³.

Congress and the American people have seen our victory during the Cold War as an opportunity to reduce military spending. During the 1990's Congress redirected funds from military spending and reduced Army manpower from 700,000 to less than 400,000 soldiers. Reduced manning required less equipment, therefore, Congress reduced funding for equipment modernization. While Congress has reduced the funds available for modernization, the Army requirement to replace aging equipment continued to increase. Before the Army could replace its aging equipment, modernization decisions had to be made. Those decisions required experimentation with digitization and the development of the prototype or medium weight brigades. Digitization and fielding of two new prototype brigades has further reduced available funds for artillery modernization. As Congress and the Department of Defense downsized the military and delayed artillery modernization, worldwide technological advances continue to

expand weapon system capabilities; today's situation is similar to U.S. artillery situation during the pre-World War I years.

The second factor affecting doctrine is changing technology. Today technological modernization is occurring in two arenas: low cost rockets and smart munitions.

Rockets and missiles, introduced during World War II, provide division and corps units long-range general-purpose fires. Currently the U.S. possesses only the 227mm multiple launch rocket system (M270 MLRS) for supporting fires. Around the world rocket systems of various types are proliferating at a rapid rate. These systems differ greatly from the highly technical M270 MLRS. First, a majority of these systems are low cost alternatives to the U.S.'s expensive MLRS. Secondly, foreign nations have chosen to build wheeled rocket launchers instead of the heavier tracked M270. Wheeled launchers reduce a weapon's weight and allow operations in build-up areas or underdeveloped regions of the world.

Most MRL systems use low cost free flight rockets capable of firing 20 to 40 kilometer and are armed with high explosive and bomblet warheads. Developed to provide area saturation fires, these low cost systems are produced in a variety of sizes from 122 to 300mm. The major exporters of multiple rocket launcher systems are the Former Soviet Union, China, Brazil, Czechoslovakia and South Africa⁴⁴. Many foreign countries now fill these long-range rockets with smart munitions.

Smart munitions, the second arena of artillery development, are designed for delivery by rockets and cannons. Currently Germany, Russia, China and South Africa produce search and destroy operations capable of destroying armored vehicles⁴⁵. Some of the smart munitions are able to search for individual targets and attack them from the top,⁴⁶ which increases their usefulness against heavy armored vehicles. These munitions incorporate technology that is

between five and ten years old and is not considered optimal by US weapon designers. However, when improved munitions are massed produced, they present a considerable threat both to artillery and maneuver forces. Meanwhile the United States has cancelled its production of the original "search and destroy artillery munitions" (SADARM) in favor of an improved version available in a few years. If the United States were involved in a war in the next three years, it would face an enemy capable of purchasing smart munitions on the worldwide market. Our potential adversaries now possess rocket and cannon artillery with greater ranges and the added capabilities of smart munitions. U.S. artillery modernization, despite modernization funding difficulties, must also adapt to the rapidly changing technologies available on the worldwide market.

Lastly, technology is affecting U.S. artillery doctrine. Technology advanced the science of artillery from World War I to the present. Likewise tactics, techniques and procedures have been updated to incorporate these new artillery capabilities. Meteorology, computerized gunnery solutions, counter-battery radars and multiple launch rocket systems are four of the most significant technological advancements since WWI.

Meteorology and computerized gunnery solutions have advanced the science of artillery. The British introduced meteorology operations during World War I⁴⁷. Meteorology is the measurement of air density, wind speed and direction, and temperature at ground level and aloft over the target area. During the early years of World War I, British officers measured wind speed, and temperature at the ground level and at various heights above the firing battery and target area to determine the effects of weather upon artillery projectiles. These measurements allowed the fire direction center to calculate precisely the trajectory of a fired artillery shell. Utilizing the physics of a ballistic trajectory, and the measured effects of weather, British

artillerymen were able to quantify the unknown variables of a projectile's flight to the target area. Incorporating the measured effects of weather into the ballistic trajectory calculations refined the science of artillery.

After World War I U.S. Artillerymen quantified the known variables of a ballistic trajectory in US Artillery doctrine as the "five requirements for accurate predicted fires"⁴⁸. Accurate target location, firing battery location, meteorological data, ammunition and weapons information management and precise computational procedures are the five elements required to compute accurate predicted fires. Artillery doctrine found in Field Manual 6-40 still requires these same elements for accurate predicted fires. The application of mathematical algorithms, the artillery slide rule, and introduction of the computer has allowed a commander and his staff to compute firing data faster and more accurately. The application of meteorology and advanced computational procedures improved the methods and accuracy of calculating an artillery projectile's trajectory.

The second technological change to affect artillery doctrine has been the introduction of the radar. Between WWI and WWII the radar was developed to detect enemy aircraft and missiles. The same technology was later modified to detect friendly and enemy artillery.

The science of radar technology was then applied to the existing science of indirect fire artillery and resulted in development of counterfire operations. Because radars have been a limited resource they have been retained at the Division or higher headquarters. Targeting cells at the division and corps headquarters, responsible for controlling counter battery fires, developed standardized tactics, techniques and procedures for controlling radar operations. As U.S. radar technology improved, so did new counterfire doctrine. Since WWII radar technology

advancements were matched with an equal change in doctrinal procedures controlling radars and their associated artillery fires.

During the 1990s, the change in technology surpassed that change in artillery capabilities. U.S. radar technological improvements allowed the Q37 counter-battery radar to detect targets beyond the range of available U.S. artillery systems. Today's Q37 can detect cannon and rocket projectiles out to fifty kilometers in standard mode and rockets beyond 100 kilometers in the extended range mode. While the Q36 and Q37 are the best radars in the world, their increased capabilities created a new problem. US radars now detect targets beyond the range of the cannon artillery and standard MLRS munitions.

Two potential solutions to this range problem are extended range MLRS rockets (45 km)⁴⁹ and the Advanced Tactical Missile System's (ATACMS). Extended Range MLRS is useful for targets identified beyond cannon range out to 45 kilometers; however, they cannot reach foreign rocket systems that range out to 80 kilometers. The ATACMS' range of one hundred and fifty kilometers solves the range problem, however its submunitions are ineffective against heavy artillery. The sub-munitions deployed by ATACMS are effective against thin-skinned vehicles and personnel in the open, however these sub-munitions have limited or no effect against cannons and self-propelled artillery. Thus future munitions or weapon systems must be developed to defeat the enemy's long-range artillery and rockets.

Since 1990 the advancement of radar technology has surpassed U.S. artillery capabilities. Current and future weapon system developments do not over come this range shortfall. Until current systems are developed that match the radar's range capabilities, the capabilities of the radar cannot be supported by U.S. artillery systems⁵⁰. Currently, the only systems capable of leveraging radar technology are air interdiction and multiple launch rockets systems.

As technology advanced into a new era of rockets and computerized artillery in the 1960s, post World War I artillery doctrine continued to influence cannon artillery units. Steeped in tradition, cannon units retained their organizational structure, and communication practices well into the late 1990s.

The 1907 drill regulations identified the firing battery as the basic unit of fire. Firing batteries were individually organized and fielded to support separate maneuver battalions. As US forces entered World War I artillery batteries were organized under the control of battalion headquarters. Three batteries of six guns, a Headquarters and Headquarters Battery and a Service Support battery were assigned to a field artillery battalion. Today's artillery batteries still adhere to this same organizational structure.

During the period 1986 to 1998 the army attempted to change this organization. A standard six-gun battery was increased to eight guns and divided into two four-gun platoons. This organization was known as three by eight (three batteries of eight guns each). Each battery was given two platoon headquarters responsible for controlling the operations of a four-gun platoon in "split battery operations." Each platoon offered several advantages over the traditional six-gun battery organization. First, each platoon was treated as a firing unit capable of executing independent fire missions. Secondly, platoon movements between firing positions allowed the field artillery battalion to provide continuous fires to the maneuver commander. Lastly, platoon operations employed FM radio communications that allowed the units to occupy widely dispersed locations. By occupying dispersed locations a firing platoon presented several small targets that an enemy could not effectively engage. Split battery operations increased a unit's survivability against enemy counterfire. Despite the tactical benefits of split battery operations the Artillery School at Fort Sill returned in 1998 to three batteries of six guns.

The post-World War I three by six organization was reintroduced because the artillery community was short manpower. Units were having difficulty manning fully eight man gun crews in the context of a general Army drawdown. Additionally, the artillery force mix needed to be reorganized to fulfill the requirements set forth in nuclear disarmament treaties.

During the Cold War eight-inch artillery had been retained in the cannon arsenal to provide long-range tactical nuclear fires. After a series of nuclear arms reduction treaties tactical nuclear projectiles were removed from the cannon artillery arsenal. Conventional eight-inch howitzer fires offered no special benefits when compared to 155 mm cannon artillery or MLRS fires. The eight-inch howitzer was expensive to maintain; required six to eight personnel to operate and provided no crew protection.⁵¹ In contrast, the recently fielded MLRS required less maintenance, fewer personnel and provided greater volumes of fires on targets at greater range. The elimination of 155mm nuclear weapons similarly reduced the number of the M109 cannons required. Since each M109 had required a crew of eight⁵² while the MLRS requires only a crew of three. Thus, two MLRS launcher crews could be fielded for every M109 cannon removed from service.

Artillery force mix studies concluded that MLRS should replace the eight-inch howitzer and a portion of the M109 cannon fleet.⁵³ As a result of these studies, the Chief of Field Artillery directed all artillery organizations to return to the three by six organization. Elimination of the nuclear threat resulted in a return to post World War I organizational structure for cannon artillery units. MLRS unit organization, not envisioned by post World War I boards continued to develop new tactics, techniques and procedures.

MLRS continued to incorporate new technologies since its inception unlike current day cannon systems. First, MLRS utilized FM radio communications; launcher crews do not lay any

wire for inter- or intra-battery communications. Rocket units rely on frequency modulated (FM) radio communications between battery, platoon, and the launchers. A second manner in which MLRS applies new technology is its onboard computer's ability to relay firing commands from the battery headquarters and platoon headquarters to any launcher. This new communication system using computers to relay firing data between computers improved the unit's ability to disperse. The relayed data created a dual system of communications replacing wire line communication that cannon units used until late 1998.

Why did the cannon fleet take so long to leverage the technology available through radios and computers? First, the M109 was not fitted with FM radios for intra-battery communication, but rather was designed for wire line communications between guns and the battery headquarters. Traditional artillery had wire line communications between higher headquarters and the firing battery. Until the late 1990s, wire line communications continued the World War I practice of laying telephone lines between firing positions and in the trench lines.

Changing to radio communications required not only additional money but also new doctrine. Secondly, platoon radios tested in the field during the late 1980s were found inadequate⁵⁴. These same radios were also considered "unprotected" against an opponent that might use nuclear weapons. A nuclear explosion would generate an electromagnetic pulse that would damage the electronic components of radios and computers. Since artillery weapons were nuclear capable, battery positions were considered a likely target for threat tactical nukes. Since wire line communications were less vulnerable to the electromagnetic pulse, the artillery community continued to rely on traditional wire line communications and doctrine did not change.

After the nuclear non-proliferation treaty was signed, the threat of tactical nuclear weapons was reduced. At the same time the Army modernized its M109 fleet with the Paladin (M109A6). Units equipped with the Paladin were fielded with secure radios mounted in each howitzer. The new radios provided both digital and voice communication between the gun crew and the platoon operations center. Radios and onboard computers build into the Paladin allowed the crew to operate using new shoot and move techniques. Battery operations were no longer required; Paladin guns could operate as platoons of three guns or in three pairs of two guns. The new Paladin doctrine prescribed dispersed gun operations. These new movement and operating techniques required extensive field training to master. Soldiers had to develop proficiency with the new equipment despite the decline in available training money.

Lieutenants during the 1980s and early 1990s using the M109A3 cannon learned battery level tactics, techniques and procedures. As commanders during the mid 1990s they employed those battery concepts when deployed to the National Training Center. Instead of conducting platoon level operations, commanders employed their guns in the traditional battery operational area. The early Paladin commanders and lieutenants serving as platoon leaders used these same battery level techniques. The only difference between the early 1990s Paladin units and post World War I self-propelled units was the Paladin unit's use of radios instead of wire. Several years have Paladin was fielded and officers have adopted the dispersed gun operations.

The transition to disperse gun operations was similar to the transition to indirect fire prior to World War I. In both cases new doctrine was adopted but a lack of funding delaying the implementation of the improved tactics, techniques and procedures. Fortunately for the artillery community, MLRS and Paladin commanders now use similar doctrine. Since the artillery community assigns officers between units armed with both weapon systems the artillery officer

has developed the experience necessary to control dispersed operations. As more lieutenants are trained in split battery and disperse gun operations, cannon artillery doctrine will be transformed. Another transition is awaiting the Army, and it also has an uncertain future; the entire army is confronted by the change associated with the Chief of Staff of the Army's vision⁵⁵.

As the military begins its transition towards an interim brigade combat team the artillery community has to assess its current indirect fire capabilities and those necessary for future conflicts. Application of current MLRS and Paladin cannon artillery systems to future fights may not be satisfactory. These systems are not precise enough for use in built-up areas. Employment of MLRS munitions requires a large area, free of non-combatants and civilian structures, approximately two kilometers in size. This area is often referred to as the munitions' surface danger area. Cannon artillery (155mm) has a surface danger area of less than 750 meters. While this is a smaller danger area, the application of standard high explosive artillery in built up areas still results in collateral damage. A possible solution to the indirect fire problem of collateral damage in build-up areas is the use of mortars. While mortars are an option to provide indirect fires in built up areas, their availability is an issue. The army has reduced the number of mortars assigned to heavy divisions from eight per battalion to six; there are no heavy mortars. The heavy mortar (greater than 240mm) was removed from the division's structure following the post World War I boards.

Now in year 2000, the US Army has only 60, 82, and 120mm mortars organic to divisional units. These light and medium mortars are augmented with light howitzers (105mm used in the direct fire role) for fires within built up areas. These mortars and light howitzers offer an acceptable risk of collateral damage⁵⁶. While mortars provide acceptable fires in built up areas U.S. military decision makers have not pursued new development of heavy mortars.

Meanwhile the former Soviet Union, Ukraine, and China have employed large numbers of heavy mortars on the battlefield. Russian, Ukraine, and German manufacturers have continued to produce heavy mortars and have developed special munitions for these systems. They have transferred technology from cannon artillery munitions and have developed laser-guided and smart munitions mortars for use in built-up areas. Meanwhile lack of sponsorship in the U.S. for heavy mortars has limited future mortar development. So while technology exists to build precision mortar munitions, decisions made by the post-World War I boards seem to have influenced current mortar operations.

Today's artillery community has responded to changes in threat and technology by providing new tactics, techniques and procedures. MLRS, computers designed to calculate the gunnery solution, radars and meteorology all provide evidence that technology has advanced since the World War I boards. Cannon artillery, however, has remained tied to the past. Battalion organization, reliance on the firing battery as the basic firing unit and reliance on existing cannon equipment are all examples of how the past has influenced the present.

CONCLUSIONS

In 1907 the artillery community initially codified indirect fire concepts learned during the period between the US Civil War and the Russo-Japanese War. These initial concepts identified the scientific elements of the indirect fire problem. Widespread distribution of the new doctrine throughout the artillery community did not occur until forces were committed into combat in France. Because the US was not a party to the war in Europe during the early years of World War I, the American people and its Army remained isolated from the war. By choosing

isolationism as a national policy the President and Congress chose not to fund preparations for the massive build-up that occurred in 1917. U.S. artillery therefore entered the war in France lacking both the equipment and the experience necessary to provide effective indirect fire. Lessons learned from World War I were captured in artillery notes, doctrinal manuals and in the findings of post-World War I boards. The findings and lessons learned from World War I continue to influence artillery doctrine today.

The first lesson from World War I is the primacy of the firing battery as the functional building block within the division. Dating back to the Civil War the battery was lowest command and control element responsible for employing artillery fires. A battery was organized to sustain itself with food, supplies and ammunition. Prior to World War I, batteries were organized into field artillery battalions for command and control, and logistical support. The battalion provided a command structure necessary to support the battery commander with a headquarters responsible for coordination for terrain, and logistical resupply. The structure developed by the end of the World War I remains essentially unchanged and the firing battery is still the basic firing unit⁵⁷. Today computers and radio-equipped self-propelled howitzers and MLRS allow a commander to employ weapons in platoons, in pairs of guns or as roving guns. Massing of individual guns on distant targets is now possible with computers and radio communications and does not require the battery organizational structure. Platoon, split-battery, and roving gun operations offer increased survivability against modern counterfire yet current artillery field manuals prohibit widespread application of dispersed firing unit operations⁵⁸. The reliance on the battery organization continues in the draft field artillery manuals currently under revision. This doctrinal position reflects an adherence to the traditional organization.

The second outcome of post-World War I boards was the Caliber Board's lasting effect on the types of cannon systems employed. During that board's investigative process field commander's opinions and experiences were recorded in the official document. These opinions and experiences framed the artillery requirements for fielding artillery equipment prior to the next major conflict. Based upon existing and developing artillery threats the board identified the caliber and range of future artillery systems. These weapons either matched or outranged all threat artillery systems that were employed in World War II. Since the World War II several classified reviews of artillery force mix were conducted.⁵⁹ Despite these subsequent reviews the basic calibers (105mm, 155, and 240mm) identified by the Caliber Board remain the accepted calibers in service today. A lack or delay of modernization in equipment has allowed several countries to again outrange U.S. cannon artillery systems.

Application of these lessons learned from the past provides both benefits and limitations on the forces incorporating those lessons. The codification of the science of artillery has benefited both maneuver and artillery units because the science of artillery has improved the accuracy of the weapons employed. Likewise the application of meteorology, and radars further improved the science of artillery and, thus, was implemented rather effectively. The application of new technology such as radios, computers and MLRS has provided new capabilities that must be incorporated in artillery doctrine. While the MLRS community has applied these new technologies to change doctrine, the cannon community has been slow to adopt new procedures and organizational structures. A new opportunity for cannon artillery to employ split unit and dispersed gun operations will develop as unit commanders gain experience with MLRS and Paladin units. Commanders that train in MLRS and Paladin units must overcome the traditions of battery operations that have existed since World War I. Since today's weapons are an viewed

as an extension of the past, future weapon systems such as truck mounted MLRS, Crusader, and smart munitions face similar obstacles since they are likely to be understood in terms of past artillery experiences.

ANNEX A, HERO BOARD FINDINGS

The twenty-one recommendations reported in the annual report of the Chief of Artillery to the Secretary of War in 1919:

a) That the proposed consolidation of the Field Artillery and Coast Artillery should not be made.

(b) That the battery combat trains be organized into ammunition batteries and battalions.

(c) That the battalion detail, now a part of the headquarters company, be made a distinct unit of the battalion.

(d) That the commissioned personnel of the battalion staff be increased.

(e) The board believes that a two-battalion' organization for the heavy regiment would be advantageous.

(f) That the trench mortar batteries, should not form part of the Field Artillery brigade but should be assigned to the General Artillery Reserve (In order to expedite the development of Trench Artillery materiel, particularly of light mobile and of heavy motorized types, a further thorough study of this question should be under-taken and pushed to a conclusion now while our knowledge and experience are fresh in the minds of Trench Artillery officers. If a Trench Artillery center should be established at once in the United States it is believed that rapid progress would be made. A considerable improvement in the present types has already been made at the A. E. F. Trench Artillery center.)

(g) That the Artillery ammunition train and a mobile ordnance repair shop be made parts of each divisional Field Artillery brigade and kept a ways directly

under the brigade commander, the Infantry ammunition train and that part of the repair shop pertaining to the Infantry being handled separately.

(h) That a battalion of mountain Artillery guns be added to the divisional Artillery brigades to make provision for accompanying guns.

(i) That the divisional Artillery be provided with a howitzer of smaller caliber than the 155 mm. howitzer.

(k) That the Corps Artillery armament consist of 155 mm. howitzers, 4.7-inch guns and 155 mm. guns.

(l) That the 75 mm gun carriage be modified to permit of high angle fire.

(m) That artillery not pertaining to divisions or corps should be organized into a general Artillery Reserve that there should be no organic Army Artillery

(n) That the Army Artillery Staff should be a small tactical staff.

(o) That many modifications should be made in ordnance, quartermaster, signal, and motor transportation equipment.

(p) That the communications personnel and equipment therefor be increased.

(q) That study and experiment should be energetically continued looking toward the early motorization of every piece of artillery that can be successfully adapted to motor traction.

(r) That aerial observation must be made more satisfactory. That an observation squadron be permanently assigned as a part of each combat division; that the aerial observers used therewith be officers of artillery, trained as observers and members of the unit for which they are adjusting; and that these officers be

required to live with their units and leave them only for the purpose of making the required adjustments.

(s) That the personnel of the Flash Ranging Service and Sound Ranging Service should be artillerymen, and that those services should be parts of the artillery organization.

(t) That the strength of our liaison detachments be considerably increased.

(u) That in addition to divisional maneuvers there should be established a course of instruction for general, field, and staff officers of both Infantry and Artillery for practical training in artillery operations.

ENDNOTES

¹ Carl von Clausewitz, *On War*, edited and translated by Michael Howard and Peter Paret, (Princeton: Princeton University Press, 1989), 291.

² United States Army, *Drill Regulations for Field Artillery (Provisional)*. (Washington: Government Printing Office, 1907), Paragraphs 233, 239, 257-260. These paragraphs identify the necessary procedures for indirect laying, changing from direct lay to indirect lay, and methods for distributing fires on the battlefield. Within this regulation are contained the technical procedure for indirect lay, indirect fire, and preliminary procedures for unobserved fires. These indirect firing procedures have been only slightly modified since 1907 to take advantage of technology and are still used in mechanized and towed artillery today.

³ Boyd L. Dastrup, *King of Battle, A Branch History of the U.S. Army's Field Artillery*, (Fort Monroe: Office of the Command Historian, United States Army Training and Doctrine Command, 1992), 145.

⁴ Ian Hogg and John Batchelor, *Artillery* (New York: Van Hoffman Press, Inc., 1992), 11.

⁵ Dastrup, 148.

⁶ *Ibid.*, 149.

⁷ United States Army, *Drill Regulations for Field Artillery (Provisional)*, Paragraph 276-282. These paragraphs 276-282 contain the basic fire missions: Continuous fires (today's FPF fires), volley fire (standard fire mission), zone fire (little used procedure today called sweep and zone), and fire at will (what is now referred to as a method of control know as "When ready").

⁸ LTC A. F. Brooke, "The Evolution of artillery and in the Great War: Part 1," *Royal Artillery Journal*, Vol. LI No. 5, (1924), 266. Quoting General Herr, formerly the artillery commander of the French VI Corps. French experiences lead them to believe that artillery was a supporting arm to the infantry armies.

⁹ J.B.A. Bailey, *Field Artillery and Firepower*, (New York: The Military Press, Oxford, 1989), 123.

¹⁰ Bailey, 120.

¹¹ Bailey, 122, and LTC A. F. Brooke, 266.

¹² Johnson House, *Toward Combined Arms Warfare: A Survey of Tactics, Doctrine, and Organization the 20th Century*, (Fort Leavenworth, KS: Combat Studies Institute, US Army Command and General Staff College, 1984), 16-17. Shellford Bidwell, and Dominick Graham, *Fire-power: British Army Weapons and Theories of War, 1904-1945*. London: George Allen and Unwin, 1982, 10-18.

¹³ Dastrup, 162.

¹⁴ Dastrup, 145.

¹⁵ War Department, "Report of the Chief of Field Artillery to Secretary of the War." *Annual Reports, War Department Fiscal Year ending June 30, 1919*, (Washington D. C.: Government Printing Office, 1919), 7-9. Hereafter referred to as *Annual Report, Chief of Field Artillery-1919*

¹⁶ *Annual Report, Chief of Field Artillery-1919*, 9.

¹⁷ War Department, *Drill and Service Regulations for Artillery, Vol. IV*, (Washington D. C.: Government Printing Office, 1916), 100-101.

¹⁸ US War Department, *General Notes on the Use of the Artillery*, translated and edited at the Army war College, (Washington, DC: Government Printing Office, 1917), 14-20. This comprehensive reference establishes tactics, techniques and procedures for the dominant forms of fires as experienced by the British and French up to that point in conflict.

¹⁹ *Annual Report, Chief of Artillery-1919*, 7, 20-21

²⁰ *Drill and Service Regulations for Artillery (Vol. IV, 1916)*, and *General Notes on the use of the Artillery of 1917* were the new doctrinal references for artillery regiments deploying to the European continent. While these documents captured the lessons learned from the British and the French they were not taught at the School of Fires due to limited training time allowed before mobilization of each of the 200 plus regiments deployed in less than 18 months. Training beyond basic skills occurred when the units arrived in France, and was conducted on the "quiet portions of the front."

²¹ Lt Col John B. Anderson, "Are We Justified in Discarding Pre-War Methods of Training," *Field Artillery Journal*, (Apr-Jun 1919), 223

²² Dastrup, 151.

²³ *Ibid.*, 151.

²⁴ *Ibid.*, 179.

²⁵ *Ibid.*, 180. The Hero Board met from December 1918 until March 1919.

²⁶ *Annual Report, Chief of Artillery-1919*, 190-191. The findings were reported in the 1919 Chief of Artillery's Report to the Secretary of War. The twenty-one findings of the Hero Board report are listed in Annex A of this paper.

²⁷ Today's artillery organization includes a Headquarters and Headquarters Battery, as well as a Service Support Battery in cannon battalion tables of organization and equipment.

²⁸ *Annual Report, Chief of Artillery-1919*, 190-191; US Army, AEF, "Report of the Board to Study the Experience Gained by the Artillery of the AEF", 1918, 7-9(hereafter cited as *Hero Board Report*)

²⁹ *Annual Report, Chief of Artillery-1919*, paragraph u, 9.

³⁰ War Department, *Annual Report of the Chief of Artillery to The Secretary of War, 1920*, (Washington D.C.: Government Printing Office, May 5, 1919) 6. This annual report contained the "Report of the Board of Officers Convened to make a study of Armament and Types of artillery material to be assigned to the Field Army. (Hereafter cited as Caliber Board Report); and "Minority Report of Board of Officers, Appointed by Paragraph 142, Special Orders No. 289-0, War Department 1918", Washington, DC: Government Printing Office, May 5, 1919. 1-3; (hereafter cited to as Minority Report)

³¹ Caliber Board Report, 4,24-25.

³² War Department, "Report of the Chief of Field Artillery to Secretary of the War." *Annual Reports, War Department Fiscal Year ending June 30, 1920*, (Washington D. C.: Government Printing Office, 1920), 4, 24-25. Hereafter referred to as *Annual Report, Chief of Field Artillery-1920*; Caliber Board Report, 24-25.

³³ Caliber Board Report, 7- 8.

³⁴ Except for the 9 1/2inch and 10 inch guns all of the recommended weapon calibers would be built before the beginning of WWII, and most are still found in today's artillery organization.

³⁵ Edward S. Farrow, *American Guns in the War with Germany*, (New York: EP Dutton and Company, 1920), 146-147; Dastrup, 165.

³⁶ Caliber Board Report, 21.

³⁷ Before WWII began U.S. industry fielded bore safe artillery fuses, and light and medium cannons as recommended by the Caliber Board.

³⁸ T.J. O' Malley, *Artillery, Guns & Rocket Systems*, (London: Greenhill Military Manuals, Stackpole Books, 1994), 86-87, 92-93, 98-99. The German Panzerhaubitze 2000 (155mm), South African G6 (155mm), Czech Dana (152) all possesses ranges greater or equal to the M109A3.

³⁹ Some National Guard Units have M109A5, an upgraded version of the M109A3. This model is similar to the Paladin without the improvements for onboard automation, and position location systems.

⁴⁰ Field Manual 6-40, *Observed Fires Procedures*, (Washington D.C.: Headquarters, Department of the Army, 1 July 1991), US 155mm artillery utilizes four types of propellants: Green bag (range: 9 km), White Bag (Range: 14 km), Red Bag or zone 7R (18 km), and Red Bag - Super 8 (range 30 km). Green and white bag propellants are the predominant powders contained in the unit's go to war ammunition load. Notice that the range recommending in 1919 falls between these two dominant powders. White bag achieves a range two kilometers greater than was recommended in 1919.

⁴¹ The M109A3 used a short 23-caliber tube, while the paladin (M109A6) uses the 39-caliber tube. The planned Crusader cannon system currently incorporates a 52-caliber tube. Increasing the length of the cannon allows the system to achieve greater rangers with the same projectile. Additional Upgrades to the M109A3 include onboard automation for the gun system; secure FM radios, and a position location determining system.

⁴² The Crusader's cannon is currently programmed to be 52 calibers in length, and increase of 13 calibers over the Paladin.

⁴³ George Seffers, "Surplus Won't Stop Shift," *Army Times*, 31 January 2000 p. 13, and Sean Naylor, "Crusaders get in line with vision of Lighter Force", *Army Times*, 13 March 2000, p. 22. These articles highlight the funding requirements to field the two "medium weight" Brigades at Fort Lewis with wheeled vehicles and digitized command and control equipment. Funding for the Search and Destroy Artillery Munitions (SADARM), extended range MLRS, and the crusader artillery system were eliminated to fund the Chief of Staff's decision to transition two brigades at Fort Lewis to medium weight

wheeled vehicle brigades. One artillery system, HIMAR (truck mounted MLRS) received funding to field HIMARS for 82nd Airborne and for the two brigades at Fort Lewis. The number of fielded Crusaders has been cut from 1138 to 480 under the current funding plan.

⁴⁴ T.J. O' Malley, 86-87. The U.S. has exported the M270 to Britain, Germany, Saudi Arabia and Israel.

⁴⁵ NGIC briefing on Smart and Near Precision Munitions presented 11-12 January 2000 at Opposing Forces Advanced Artillery Munitions conference at Threat Doctrine Directorate, Fort Leavenworth, Kansas.

⁴⁶ Top-down protocol refers to munitions that attack a target by propelling a penetrating charge into the top surface of a vehicle. Top-down munitions are effective because they attack the top of the vehicle where the thinnest armor plating is found on most vehicles.

⁴⁷ J.B.A. Bailey, 150. Prior to 1914 predicted fires were technologically not possible. Quantifying the variable of weathers affects on a projectile allowed the army's of WWI to calculate the impact point of a projectile with ballistic characteristics.

⁴⁸ FM6-40, 1-3 to 1-4. The five elements of accurate predicted fire are discussed in detail in Chapter One of this field manual.

⁴⁹ Field Manual 6-60, *Multiple Launch Rocket System (MLRS) Operations*, (Washington, D.C.: Headquarters, Department of the Army, 23 April 1996) p.1-6, 1-8, 1-9. The standard rocket (M26) can be fired between 8 and 30kms, while the extended range rocket can be fired out to 45 kms. The advanced tactical missile system (ATACMS) M39 block I can be fired 25 to 150 kms, while the extended range Block IA can be fired between 100 and 300kms.

⁵⁰ While US artillery systems cannot leverage the capabilities of the Q37 radar, US Air Force aircraft have been directed against artillery targets identified by U.S. radars. While not an optimal solution, aircraft with guided missiles or dumb bombs can render enemy artillery ineffective. One artillery submunition under going testing is brilliant anti-tank (BAT). This submunition has the capability to loiter over a target area until it identifies a target, and then attacks it from the top. This submunition is carried to the target area by ATACMS. Corps or Theater level headquarters usually controls ATACMS usage.

⁵¹ The eight-inch howitzer had an optional canvas cover to provide limited crew protection from the weather, however soldiers were not provided any protection against fragmentation nor small arms fire. For all practical purposes the soldier were as exposed as artillerymen operating a towed howitzer.

⁵² Five personnel are required to man a M109 during peacetime firing and the ammunition vehicle required a crew of three bringing the total to eight.

⁵³ Fort Sill, "Field Artillery Organizational and Requirements Study" (Study 1985-1996 aka Legal Mix VI), (Fort Sill: Directorate of Combat Developments, 1986), 13,14

⁵⁴ During the author's assignment to Second Armored Cavalry Regiment, small unit radios (AN/PRS - 9) were tested in the M109A3 howitzers as a potential replacement for wire line communications. Handheld radios required battery replacement every twelve hours unless the unit was issued the vehicular mounts. Unfortunately the vehicular mounts were not available, so the unit relied on hundreds of expensive non-rechargeable batteries for a seven-day exercise. Battery costs were so prohibitive that units returned to

wire line communications or as an alternative, soldiers voice relayed information across a unit's position area. During this test, radios were ineffective because the Army supply system was unable to field the required vehicular mounts and amplifiers. Ironically these radios transmitted less than a mile, and were totally inadequate for inter-battery communication. Units relied on the platoon leader's and commander's vehicular FM radios.

⁵⁵ Gen Eric Shinsecki, Army Vision Statement, [Chief of Staff of the Army Website], (12 October 1999 accessed 15 Oct 99), available from <http://www.hqda.army.mil/ocsa/vision.htm>

⁵⁶ Laser guided munitions from close air support, and direct fire missiles from attack helicopters are two means of close support fires that are acceptable in built up areas that require limited collateral damage.

⁵⁷ Field Manual 6-50, *Cannon Tactics, Techniques and Procedures, Battery*, (Washington D.C.: Headquarters, Department of the Army, 23 December 1996), paragraph 1-1.b. In paragraph 1-1.b "The field artillery cannon battery is the basic firing element of the cannon battalion regardless how it is organized.

⁵⁸ Doctrine also inhibits changing the organization structure "...in no way should the references to platoon-or battery-based organizations be construed as the structure for operational employment. Rather, the terms pertain solely to organizational structure." Later references to platoon operations controlled by the battalion S-3 indicate that control of platoon or smaller sized elements is the "least desirable."

⁵⁹ Since the Caliber Board, the Army has conducted several artillery force mix boards known as "Legal Mix". These classified reviews of artillery structure identified the composition of artillery force structure after WWII to the present. The published unclassified report from the Caliber board captured both concurrence and non-concurrence from the field commanders, today's artillery force mix documents are both classified nor seek concurrence from field commanders but instead are based upon war games and simulations. A direct outcome of these force structure boards has been the lack of ownership that existed after the Caliber Board.

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